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A PRELIMINARY COMPARISON OF THE GRIDGEN AND THE EAGLE COMPUTATIONAL FLUID DYNAMICS (CFD) GRIDDING PACKAGES

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INTRODUCTION

The solution of complex fluid flow problems using computational fluid dynamic (CFD) techniques is often highly dependent upon the distribution of grid points within the solution domain. A poor grid can either lead to an erroneous solution or cause the CFD program to crash. A well-defined grid for the problem at hand, however, not only increases the accuracy of the solution, but also reduces the time needed for convergence to that solution.

Simple gridding algorithms for two-dimensional problems have been around for many years. Since these were first used to determine the inviscid flow over regular geometric sections, the grid spacing algorithms were often quite simple. Once more complex two-dimensional geometries were investigated, the grid generation process became more involved. Computation of viscous flows introduced the problems associated with boundary layer separation and turbulent eddies. Even for simple steady flows in the turbulent regime, the user must have adequate knowledge of the flow field in order to distribute an appropriate grid. If the section of interest is traveling within the transonic or supersonic regimes, the shock waves must be captured with enough resolution to enable the solver to model the varying physics of such a flow field. Once the problem of interest becomes a three-dimensional problem, the gridding process takes a quantum leap in complexity and effort.

It has become apparent that for most of the CFD problems of interest to the Navy the primary burden is that of grid generation. The person responsible for the gridding of the fluid flow field can have a huge effect upon the solution to the problem. Therefore, it has become imperative for engineers to use effective tools with which to develop accurate grids for the intended problem. These tools must be easy to use, must have the capability to develop grids for a variety of geometries in various flow regimes, and must be able to communicate with both surface modeling programs and CFD programs. In addition, these tools must be upgradeable to use the most advanced algorithms for grid generation, and to be able to run on the fastest hardware possible.

APPROACH

The approach of this work was to speak with current users of both the GRIDGEN and the EAGLE grid generation packages. From these discussions, the general merits of the two packages were obtained. The author then reviewed user's manuals and technical reports on both packages to reaffirm the capabilities of the two. In addition, a demonstration of EAGLE was given by Troy Hollingsworth of the Naval Undersea Warfare Center Detachment, New London, CT.

DESCRIPTION OF THE GRIDGEN PACKAGE

GRIDGEN [1] was developed by the Fort Worth Division of General Dynamics Corporation for the Air Force's Wright Research and Development Center in the late 1980's. The current Version 8 of the software runs primarily on Silicon Graphics Inc. (SGI) workstations, and is distributed by Reese Sorenson at NASA Ames. The bulk of the package is broken up into three main pieces as shown in figure 1. GRIDBLOCK is used to read in the overall geometry and to break the solution domain into multiple blocks for grid generation. GRIDGEN2D is used to grid the two-dimensional surfaces into appropriate meshes for the flow regime and the geometry being investigated. GRIDGEN3D allows the user to distribute grid points into the three-dimensional space between these two-dimensional surfaces in a smooth manner. Version 9 of the software, which is scheduled to be released in November 1994, is reportedly combining the GRIDBLOCK and the GRIDGEN2D modules into one piece since many of their functions overlap.

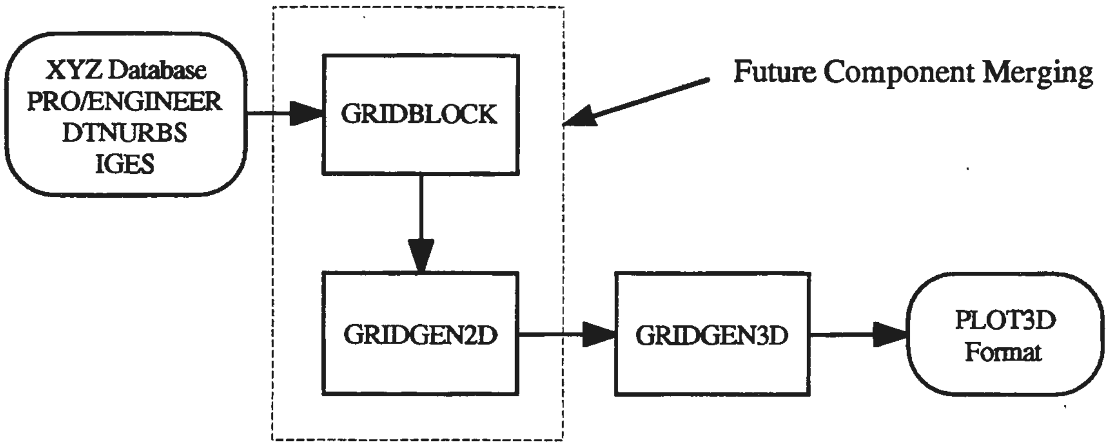

Figure 1: GRIDGEN Flow Chart

GRIDGEN [2] has been used successfully in creating two-dimensional surface grids and three-dimensional volume grids on many problems of interest to the Navy. Submarine hulls, fins, and other appendages have been modeled for various Reynolds numbers. Eckart [3] spoke highly of the program's ability to create complex curves and surfaces. However, once the two-dimensional grids are set up for the intended surface, it is apparently difficult to manipulate those grids without starting over from scratch. Any grid generation routine will have troubles when the grid spacing requirements get very tight, such as those required for higher Reynolds number flows. But GRIDGEN is reported to have an interpolation problem when the grid gets exceedingly tight. For a sail plane with low Reynolds number flows this is not a problem, but for a fully turbulent submarine flow it is something to consider. Coleman [4] reported that the three-dimensional grid smoothing was not as impressive as expected, and consequently he has written many of his own routines for that portion of the grid generation problem. In addition, Coleman has uncovered some bugs in his five year experience with the package. Neither Eckart nor Coleman reported using any type of a scripting language with GRIDGEN, which would supposedly increase the speed with which an engineer could alter the grid once it has been set up. It is hoped that many of these shortcomings will be addressed in the November release of Version 9.

The input into GRIDGEN is often taken in the form of an XYZ database that can be generated by CAD programs such as PRO/ENGINEER and DTNURBS. It can also receive information in the Interim Graphical Exchange Standard (IGES) format. The output from GRIDGEN is in NASA Ames' PLOT3D format, which allows visualization and input to a suitable CFD code. GRIDGEN comes with a graphical user interface (GUI) that has a toggle to reduce the number of displayed options in order to reduce the complexity for new users. Even with this toggle, average learning times for the current version were around four weeks. Customer support is provided by NASA Ames and is reported to be good. The user's manual appears to be extensive and well written.

DESCRIPTION OF THE EAGLE PACKAGE

EAGLE [5] was developed by the Mississippi State University NSF Engineering Research Center for Computational Field Simulation in the late 1980's. The current version of the software runs primarily on SGI workstations, although extensions are available for other platforms. The code is maintained by Mississippi State University. EAGLE is broken up into two main pieces as shown in figure 2. EAGLEView is a GUI that reads in the appropriate geometry and lets the user communicate with the two modules that do most of the grid generation work. EAGLE SURFACE is used to grid the two-dimensional surfaces into appropriate meshes for the flow regime and the geometry being investigated. EAGLEGRID allows the user to distribute grid points into the three-dimensional space between these two-dimensional surfaces in a smooth manner.

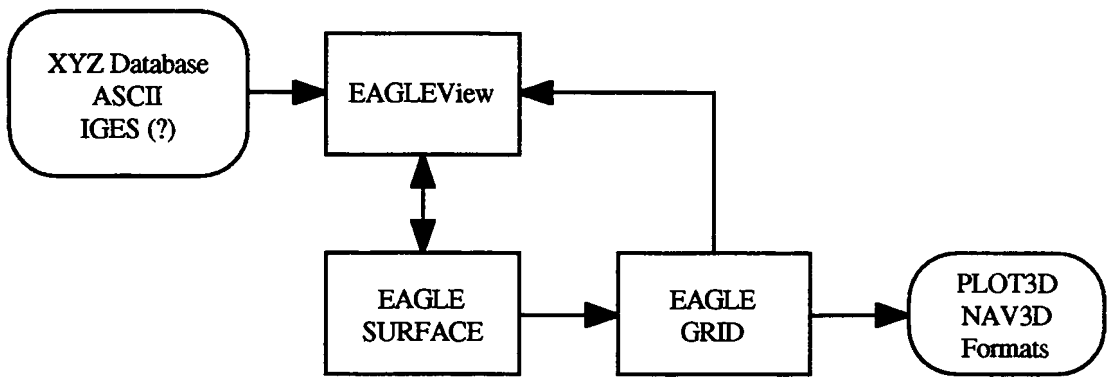

Figure 2: EAGLE Flow Chart

EAGLE [6] appears to have most of the same capabilities noted in the GRIDGEN package. It has the ability to create smoothly varying two-dimensional grids for various problems of interest to the Navy. From the beginning, the developers of the package have put state-of-the-art grid generation capabilities at a higher priority than the user interface. They have continually updated the core algorithms before addressing the user interface. EAGLE appears to offer good tools with which to create and manipulate curves and surfaces. The large number of options allow the user to quickly home in on the two-dimensional grid that is desired. With the use of a high-level scripting language, the user can also change a few parameters and re-run only the portion of the grid generation process that is affected. This capability can save the user a tremendous amount of time. The main drawback with EAGLE is the inability to smooth three-dimensional grids interactively. Hollingsworth [7] has written algorithms to perform some smoothing tasks in a batch mode. The demonstration given by Hollingsworth showed an involved, but consistent, GUI and many very useful features for grid optimization.

The input into EAGLEView is often taken in the form of an XYZ database that can be generated by various CAD programs. The reported ability to receive information in the IGES format does not appear to be usable at this time. Hopefully, the ability to perform this valuable translation will be available in the next software release. EAGLE can output the final grid in NASA Ames' PLOT3D and also in NAV3D formats [8]. The EAGLEView GUI allows the user to interactively visualize the geometry for quick turnaround times, often eliminating the need to use PLOT3D before doing the CFD analysis. Average learning time for EAGLE was reported to be approximately two weeks. Unfortunately, the user's manual appears to be rather weak and not as

well written as that for GRIDGEN. The developers are aware of this shortcoming and host regularly scheduled short courses to jump-start new users. Future plans for EAGLE include the further integration of its grid generation capabilities with those of CAD surface generation programs and CFD solvers via the National Grid Program, which is sponsored by the NSF.

COMPARISON OF THE TWO PACKAGES

The principal advantages and disadvantages of GRIDGEN are listed in tables 1 and 2, respectively.

Table 1: GRIDGEN Advantages and Disadvantages

GRIDGEN	
Advantages	**Disadvantages**
Well defined user base	Difficult to use
Regular software updates	No scripting ability
Three-dimensional smoothing	Non-interactive visualization
Good interaction with supporting programs	Problems with tight meshes
Good users manual and support	No in-house user base

Table 2: EAGLE Advantages and Disadvantages

EAGLE	
Advantages	**Disadvantages**
In-house user base	Poor interaction with CAD programs
Regular software training	Fair user base
Ease of use	Poor users manual
Interactive visualization	
Scripting capability	
Distribution is free	

It can be seen from comparing the two tables that EAGLE has fewer disadvantages than GRIDGEN. From this preliminary investigation, it appears that the two programs are about equal in capabilities for problems of interest to the Navy. Therefore, the areas that make the difference are the future support for each package in the Government and in industry, and the user friendliness of the programs. According to Mississippi State University, the EAGLE package is a part of the National Grid Project, which is being supported by the NSF. This should secure the future of EAGLE, but the large established user base for the GRIDGEN package is also of considerable merit. EAGLE's GUI was impressive and certainly allowed the user ample flexibility with which to generate suitable grids for fluids problems. If future releases of EAGLE can communicate with various CAD and CFD codes, and if the NSF continues to support the package, it would be hard to beat EAGLE.

CONCLUSIONS AND RECOMMENDATIONS

The principal conclusion is that, based upon merit alone, GRIDGEN and EAGLE appear to be equally suited to developing complex grids for CFD applications. Both packages are capable of creating two- and three-dimensional grids that are adequate for most problems of interest to the Navy. The ease of use, the quick availability, and the in-house knowledge of the use of EAGLE give it the upperhand as a short-term solution to NUWC Division Newport grid generation problems. In the long run, however, the wide user base and attention that are being given to GRIDGEN may have some benefits to the Division.

Another option that the author has experience with is the Interactive Graphics for Grid Generation (I3G) gridding package [9], which is distributed by Science Applications International Corporation. Although not as capable or as well developed as either the GRIDGEN or the EAGLE packages, it is readily available on Hewlett Packard workstations within NUWC Division Newport.

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